

DESIGN AND ANALYSIS OF WHEEL ASSEMBLY OF AN ATV

NITISH MALIK & PRAKHAR AGARWAL

Department of Automobile Engineering, Rustamji Institute of Technology, BSF Academy, Tekanpur, Madhya Pradesh, India

ABSTRACT

Wheel assembly, oftenly called Hub assembly is the major automotive assembly part of an automotive vehicle. For any vehicle, its dynamics and control behaviour is mainly controlled by the design of the Wheel assembly. Depending upon the purpose and usage of the vehicle, design considerations and methodology are generally different. This is mainly concerned with the All-Terrain Vehicle. Through this, the total unsprung mass of the vehicle was decreased and the dynamic performance of the vehicle was increased.

KEYWORDS: *Caliper, Disc, Hub, Knuckle, Wheel alignment parameters, Forces and Moment, Solid Works 15.0, ANSYS 12.1*

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INTRODUCTION

As the name suggest, Wheel assembly consists of various component, as shown in figure 1, that are assembled together to get a single complete unit. It has the main function of allowing the free rotational motion of the tire and act as an intermedaior, between the wheel and other controlling systems to transfer the forces, inputs and responses from the

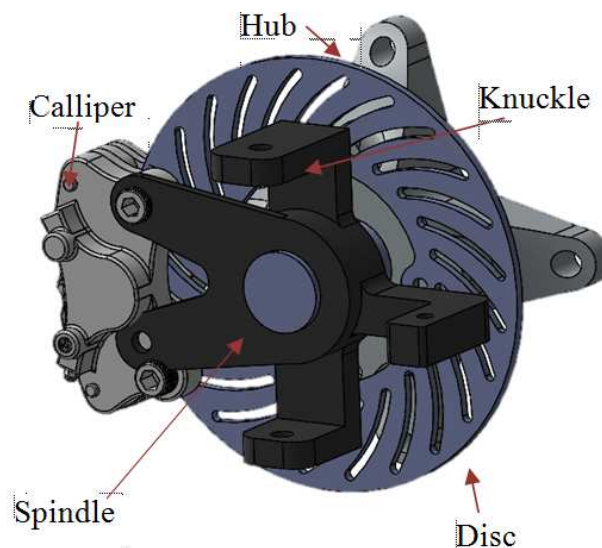


Figure 1: Components of Wheel Assembly

The complete wheel assembly is attached to the rim of the wheel, with the four mounting points on the one side and from the knuckle side, it is attached to the suspension control arms and the tie rod including both, with the three points.

METHODOLOGY

Every component of the wheel assembly follows a different designing procedure as they need different input variables which have to be decided before finalizing the initial sketch of the components.

Depending upon the design consideration, the various departments like suspension, steering and brakes etc. set up their limits such that, to get the required performance from the vehicle, these perimeters should lie between these ranges.

Once this was set, Suspension and Steering geometries were plotted in software, LOTUS SHARK v5.01 and both static and dynamic behaviour of respective departments were carefully analysed and necessary changes were made.

Table 1: Wheel Alignment Parameters

S. NO	Parameters	Values
1	Camber angle	0°
2	Caster angle	2.43°
3	Kingpin axis inclination	6.29°
4	Scrub radius	46.42 mm
5	Toe	0°
6	Rack length	12 inch
7	Rack travel	75 mm
8	Wheel base	1360 mm
9	Front track width	1200 mm

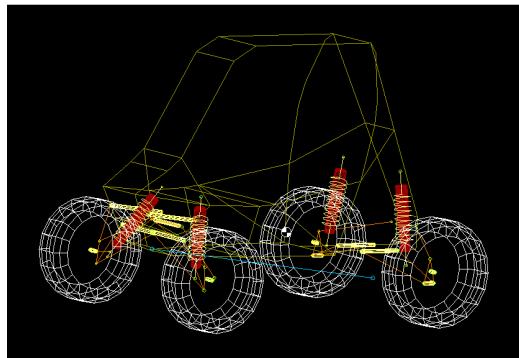


Figure 2: Suspension and Steering Geometry in Lotus Shark V5.01

Depending upon the wheel alignment parameters like camber angle, castor angle etc and performance parameters of the respective departments like turning radius, bump travel, etc.; we will get the locations of the various hardpoints of the knuckle and king pin offset.

Before finalizing these points, check for the changes in the online wheel alignment parameters, during the three different dynamic conditions like bump, steer and roll. Changes should not cross the set limits.

After getting the steering and suspension hard points, find out the caliper mounting points on the knuckle, which depends upon the size of the caliper and the disc diameter. Caliper mounting points should be such that, pad of caliper are fully overlapping the disc having a pre-assumed pitch circle diameter and the outermost periphery of caliper is maintaining some clearance from the rim of the wheel.

Also one should check, whether caliper and hub of the wheel was having enough clearance or not. If yes then OK, but if not then check, on how much more gap was needed there and re-adjusted the entire component to get the desired

clearance.

After getting all the hard points of the knuckle, a rough 2D sketch of the these points along with the clearance was made in the CAD software Solid works 15.0.

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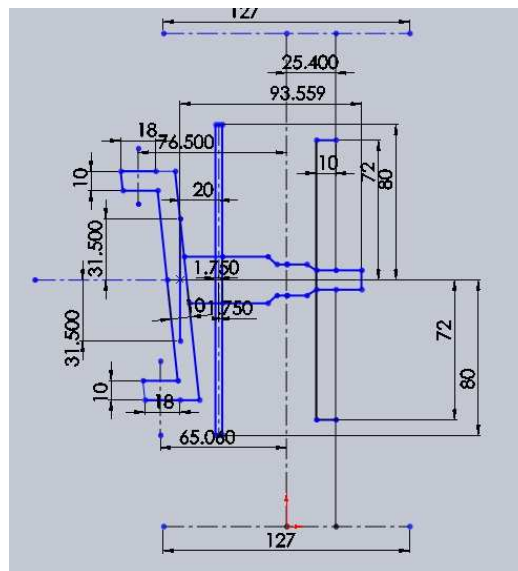


Figure 3: 2D Rough Sketch of Wheel Assembly

Then, further proceeded on getting the shapes of the component, depending upon the feasibility, ease of manufacturing and aesthetics of the assembly

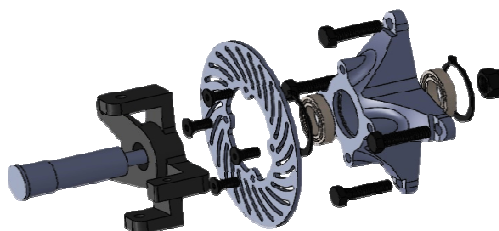


Figure 4: Exploded View of the Finalized Wheel Assembly

Here, other components like bearing, circlip and castle nut were selected as per the OEM standards.

FORCE CALCULATION AND ANALYSIS

Depending on the components of the assembly, different types of forces acts on them. By using the simple laws of mechanics, we can find out the magnitude of the forces acting on them.

Knuckle

In different scenarios like bump, cornering, braking etc. there were different types of forces acting on them.

We took the worst scenario of having braking during the cornering on a bump. In that case we had considered all the forces that can act.

EN 8 material was selected for the manufacturing of the knuckle

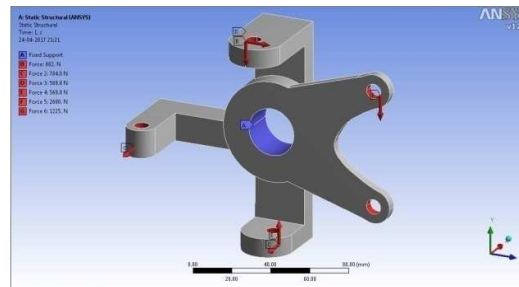


Figure 5: Boundary Conditions

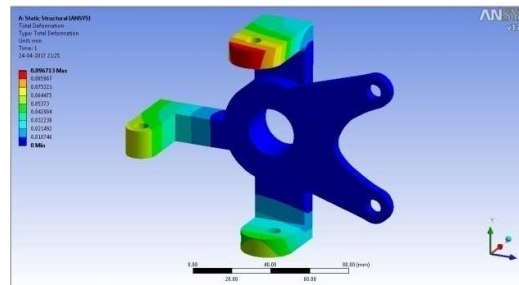


Figure 6: Deformation

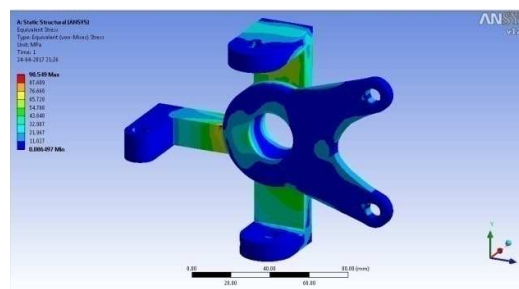


Figure 7: Stress Profile

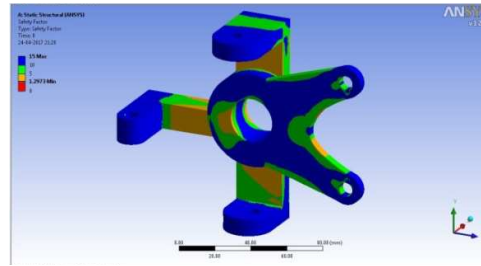


Figure 8: Fatigue F.O.S

Table 3: Analysis Results of Knuckle

Def.	Stress	F.O.S	Fatigue F.O.S	Life
0.096 mm	98.54 MPa	2.53	1.29	10^6 cycles

Hub

Hub is the part of the wheel assembly, on which the rim and disc are bolted and is press fitted on the spindle, through roller bearing.

During the analysis, it is fixed from the bearing sheet while applying 2 torques (driving & braking) and 3 forces (two bump & lateral) on the respective hard points.

Table 4: Analysis Results of Wheel Hub

Def.	Stress	F.O.S	Fatigue F.O.S	Fatigue Life
0.303 mm	50.231 MPa	3.981	1.64	10^8 Cycle

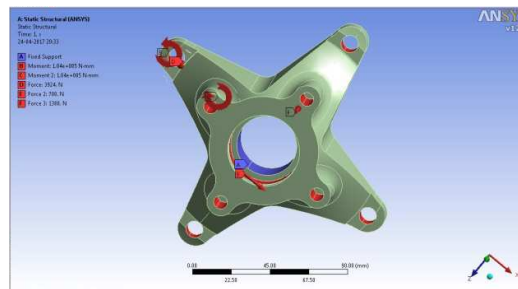


Figure 9: Boundary Conditions

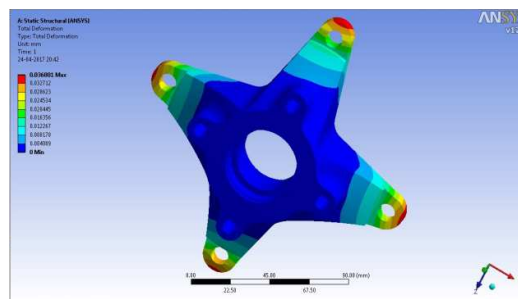


Figure 10: Deformation

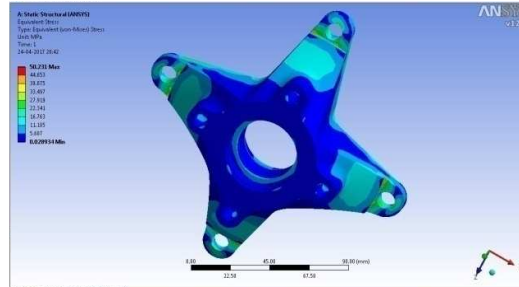


Figure 11: Stress Profile

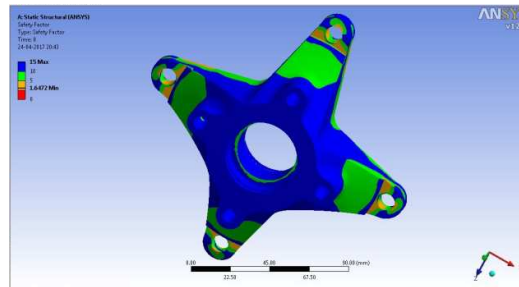


Figure 12: Fatigue F.O.S

Table 5: Material Selection of Disc

Material	Density	Conductivity	Hardness
SS 410	7.9 gm/cm ³	24.90 W/m.K	180 BHN
AISI 1018	7.8 gm/cm ³	21.09 W/m.K	135 BHN
EN 8	7.8 gm/cm ³	52.30 W/m.K	201 BHN

Disc

The internal diameter of rim is 10 inches, so it constrained the size of the disc. By considering proper clearance, maximum diameter of the disc was selected.

During disc analysis, kinetic energy of the vehicle, in terms of heat flux which was imparted on the contact patch were of the disc and calliper pad.

We had decided AISI 1018 material as manufacturing of brake disc, as it has very high conductivity and sufficient strength.

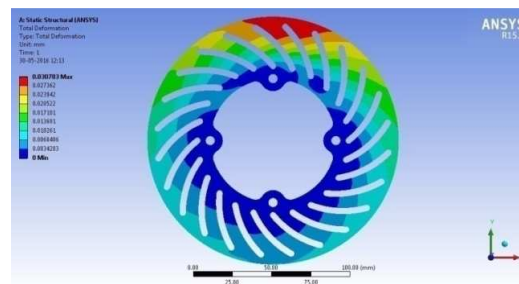


Figure 13: Deformation

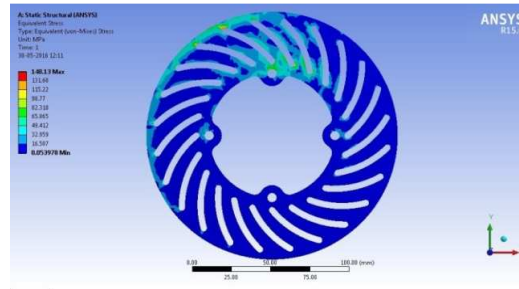


Figure 14: Stress Profile

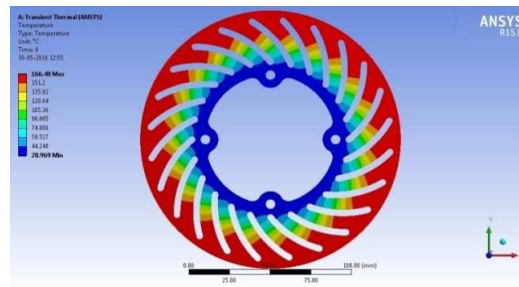


Figure 15: Temperature Profile

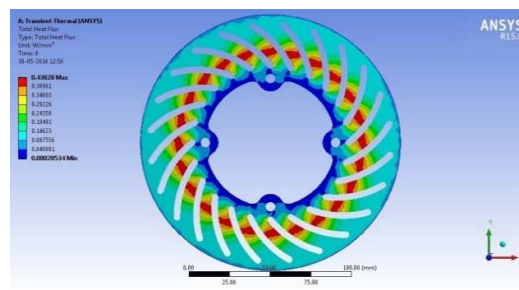


Figure 16: Heat Flux

Table 6

Def.	Stress	Temp.	Heat Flux
0.030 mm	148.13 MPa	166.4 °C	0.438 W/mm ²

CONCLUSIONS

After the designing phase, the various components of the wheel assembly are tested for the various types of tracks like Suspension & Traction, endurance racing in the BAJA SAE INDIA 2017 main event at Pitampur, Indore. In endurance race, the vehicle was run about 4 hours continuously. There was no failure observed, in the wheel assembly and unsprung mass of the vehicle was reduced, which further enhances the performance of the vehicle. The various components of the wheel assembly were found safe and gave the desired performance.

As a conclusion, the Original Equipment Manufacturer (OEM) wheel assembly was replaced by the light weighted customised wheel assembly.



Figure 17: Prototype Tested in BAJA SAE INDIA 2017 ATV

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